Source of Acquisition
NASA Ames Research Center

Measurement of vortex strength and core diameter in the wake of a hovering rotor

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Summary

Detailed hot wire measurements have been acquired in the tip vortex of a three-bladed model tilt rotor in hover. Testing was conducted at a rotor tip speed of 752 ft/sec, a Reynolds number (based on blade tip chord) of 1.77 x 10^6, for thrust coefficients up to 0.0160. Figure 1 shows the hot wire mounted above the inverted rotor at the Outside Aerodynamic Rotor Facility (OARF) at NASA Ames Research Center.

Strobed shadowgraph flow visualization was used to define the vortex trajectory as an aid in hot wire positioning. Considerable variations in tip vortex structure with time were observed, even from the same blade, under essentially uniform test conditions. The only velocity signatures analyzed were those corresponding to passage of the probe directly through the center of the vortex. These time histories were ensemble averaged after compensating for jitter in the vortex arrival time at the probe, thereby retaining the core structure with minimal smearing. An example of a mean velocity signature, after ensemble averaging, is shown in Figure 2. The mean velocity signature was analyzed under the assumption of constant (unknown) translation speed of the vortex filament past the fixed probe. The translation speed of the vortex is deduced and the vortex strength and core diameter inferred.

The results were highly unexpected. The indicated vortex strength is seen to decrease rapidly after first blade passage. In addition, the core radius is seen to decrease with increasing wake age, not increase as might be expected from simple diffusion.

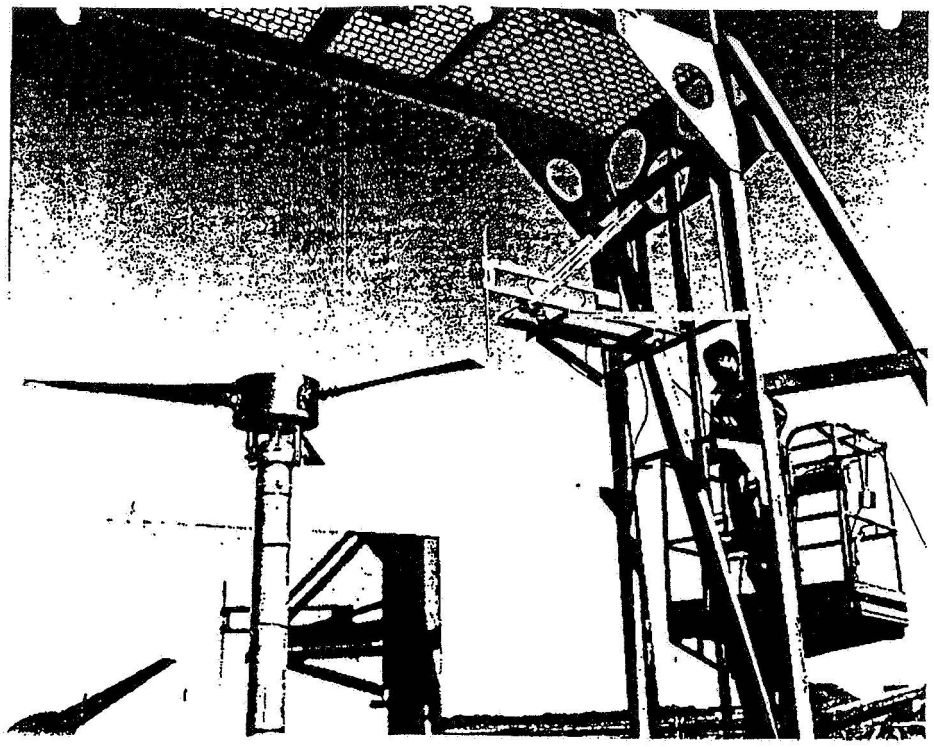

Figure 1. Installation photograph showing hot wire mounted above inverted rotor

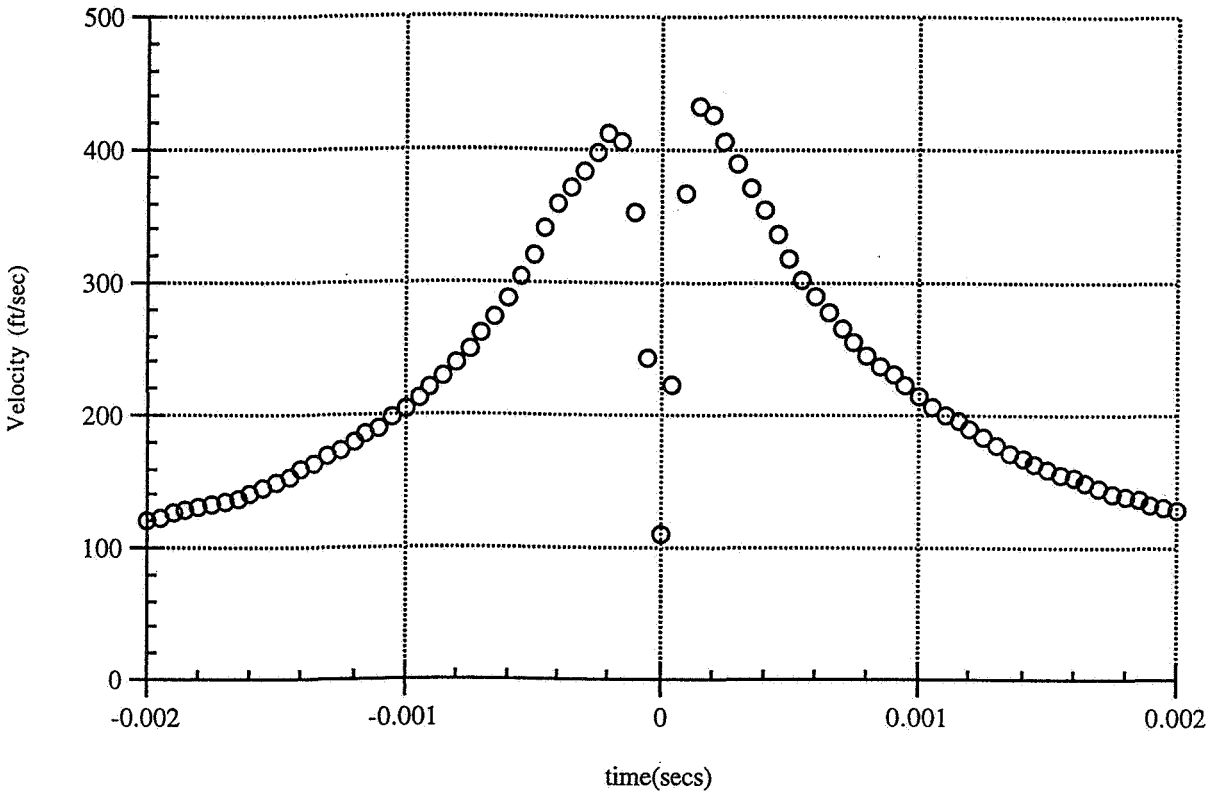

Figure 2. Mean time history at wake age of 144 degrees for C_T = 0.0149